Physical and Data Link Layer Cheat Sheet

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Transmission Media

Transmission media is a communication channel that transmits information from the source/transmitter to the receiver

Wired Media

Type	Speed	Cost	Use Case
Twisted Pair	Up to 10 Gbps	Low	LANs, Telephone
Coaxial Cable	Up to 1 Gbps	Medium	Cable TV, broadband
Fiber Optic	Up to 100+ Gbps	High	High-speed backbone, ISPs

Wireless Media

Type	Range	Speed	Use Cases
Radio Waves	Short to Medium	Medium	WLANs, mobile phones
Microwaves Unidirectional	Long	High	Satellite links, cellular
Infrared (IR)	Very short	Low	Remote controls
Satellite	Global	Medium to High	Global communication

Types of Parity

Even Parity	Odd Parity
Total number of 1s (including parity bit) must be even.	Total number of 1s (including parity bit) must be odd.

Limitation: Detects only odd number of bit errors (fails if two bits flip).

Real-World Applications

PARITY	Used in RAM error detection.
Checksum	TCP/IP headers, UDP.
CRC	Wi-Fi, ZIP files
Hamming Code	ECC memory, satellite communication.

Introduction to MAC Protocols

MAC (Media Access Control) protocols determine how devices share a communication channel to avoid collisions.

Used in: Ethernet (wired) and Wi-Fi (wireless).

Goal: Ensure fair and efficient transmission.

CSMA/CD

CSMA/CA, is a channel access method used in wireless networks, particularly in IEEE 802.11 (Wi-Fi), to manage access to the shared communication channel and prevent collisions.

How CSMA/CA Works

1. Carrier Sense (CS):
Device checks if the channel is idle.
2. Collision Avoidance (CA):
Uses RTS/CTS (Request to Send / Clear to Send) to reserve the channel.
Waits for DIFS (DCF Interframe Space) before transmitting.
3. Random Backoff Timer:
If busy, waits for a random time (contention window) before retrying.

Framing

Framing is the process of dividing a continuous stream of data into manageable chunks called frames for transmission.

Framing Techniques

Technique	Description
Character Count	Frame starts with a count of the number of characters in the frame.
Byte Stuffing	Special characters added to distinguish data from control info (e.g., FLAG -> ESC FLAG).
Bit Stuffing	Inserts 0 after a sequence of 5 continuous 1s to avoid confusion with frame delimiters.
Clock--based (SONET)	Uses synchronization signals to mark frame boundaries.

Cyclic Redundancy Check (CRC)

Uses polynomial division to generate a checksum (CRC code).

Steps:

1. Choose a predefined generator polynomial (e.g., $x^3 + x + 1 \rightarrow 1011$).
2. Append n zeros to data (where n = degree of polynomial).
3. Divide modified data by polynomial (using XOR).
4. Append remainder (CRC) to original data.

Advantage: Detects all single-bit, double-bit, and odd-length burst errors.

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Hamming Code

Adds redundant bits to detect and correct single-bit errors.

Steps:

1. Insert parity bits at positions that are powers of 2 (1, 2, 4, 8...).
2. Calculate parity for overlapping bit groups.

Example:

1. Data: 1001
2. Encoded: _ _ 1 _ 0 0 1 (positions 1,2,4 are parity bits)

Calculate parity:

P1 (positions 1,3,5,7): ? + 1 + 0 + 1 → Even parity → 0

P2 (positions 2,3,6,7): ? + 1 + 0 + 1 → Even parity → 0

P4 (positions 4,5,6,7): ? + 0 + 0 + 1 → Odd parity → 1

Final Hamming code: 0011001

Error Correction: Receiver recalculates parity to locate and flip the erroneous bit.

Flow Control Methods

Method	Efficiency	Complexity	Best For
Stop & Wait	Low	Low	Low-speed links
Go back N	Medium	Medium	Moderate
Selective Rep	High	High	High-speed
Leaky Bucket	Controlled	Medium	Traffic shaping

Switching Techniques

Switching is a technique used to transmit data across a network from source to destination. It determines how data is routed and delivered between network devices

Comparison of Switching Techniques

Circuit	Packet	Message
Dedicated communication path,before data transfer.	Data is divided into packets sent independently	Entire message is stored and forwarded.
Consistent and reliable	Efficient use of bandwidth.	No need for a dedicated path.
Wastes bandwidth when idle.	Packets may arrive out of order.	Delays due to store-and-forward.
Telephone networks	Internet, VoIP	Email systems

Technique Description Advantage Disadvantage Use Case

Error Types

Error Type	Description	Example
Single-bit	One bit is flipped (0→1 or 1→0)	010 → 011
Burst Error	Multiple consecutive bits are corrupted	001100 → 110011

Types of Errors in Networking

Error Detection Techniques

Parity Check

Adds an extra bit (parity bit) to make the total number of 1s even (even parity) or odd (odd parity).

Comparison: CSMA/CD vs. CSMA/CA

Feature	CSMA/CD (Ethernet)	CSMA/CA (Wi-Fi)
Medium	Wired	Wireless
Collision Handling	Detects collisions	Avoids collisions
Duplex Mode	Half-duplex	Doesn't require full-duplex
Mechanism	Listens while transmitting	Uses RTS/CTS/ACK
Efficiency	Faster in wired networks	Slower due to overhead
Backoff Algorithm	Binary Exponential	Similar, but with DIFS/SIFS

Checksum

Sender computes a checksum (sum of data bytes) and appends it to the data. Receiver recalculates and compares.

Steps:

1. Divide data into fixed-size segments (e.g., 16-bit words).
2. Sum all segments (ignore overflow).
3. Take 1's complement (invert bits) → Checksum.
4. Append checksum to data.

Limitation: Weak against certain errors (e.g., reordered data).